



# Fermi

The Gamma-ray Large Area Space Telescope

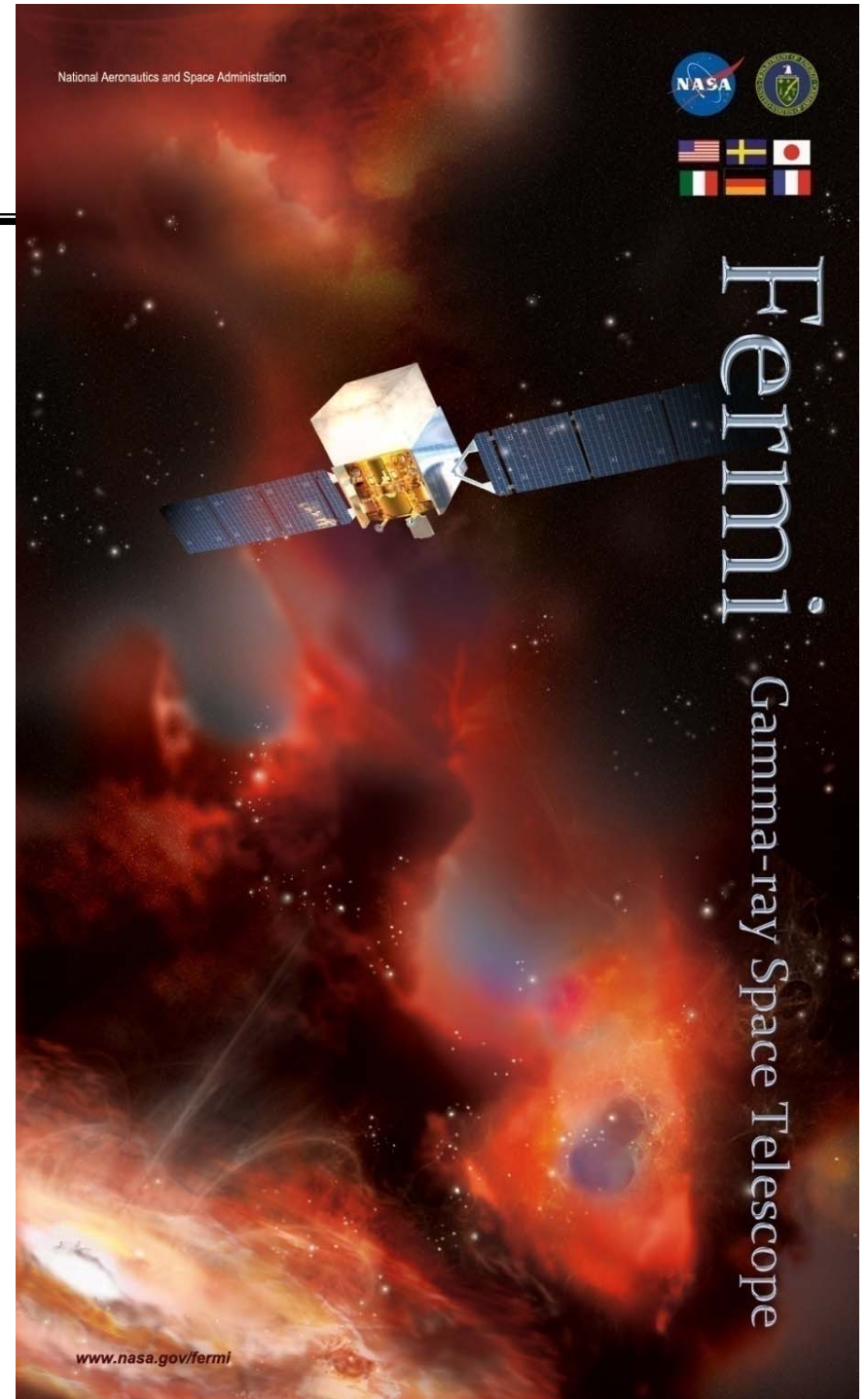
## Mission Status

Julie McEnery

On behalf of the Fermi mission team

see <http://fermi.gsfc.nasa.gov> and  
links therein

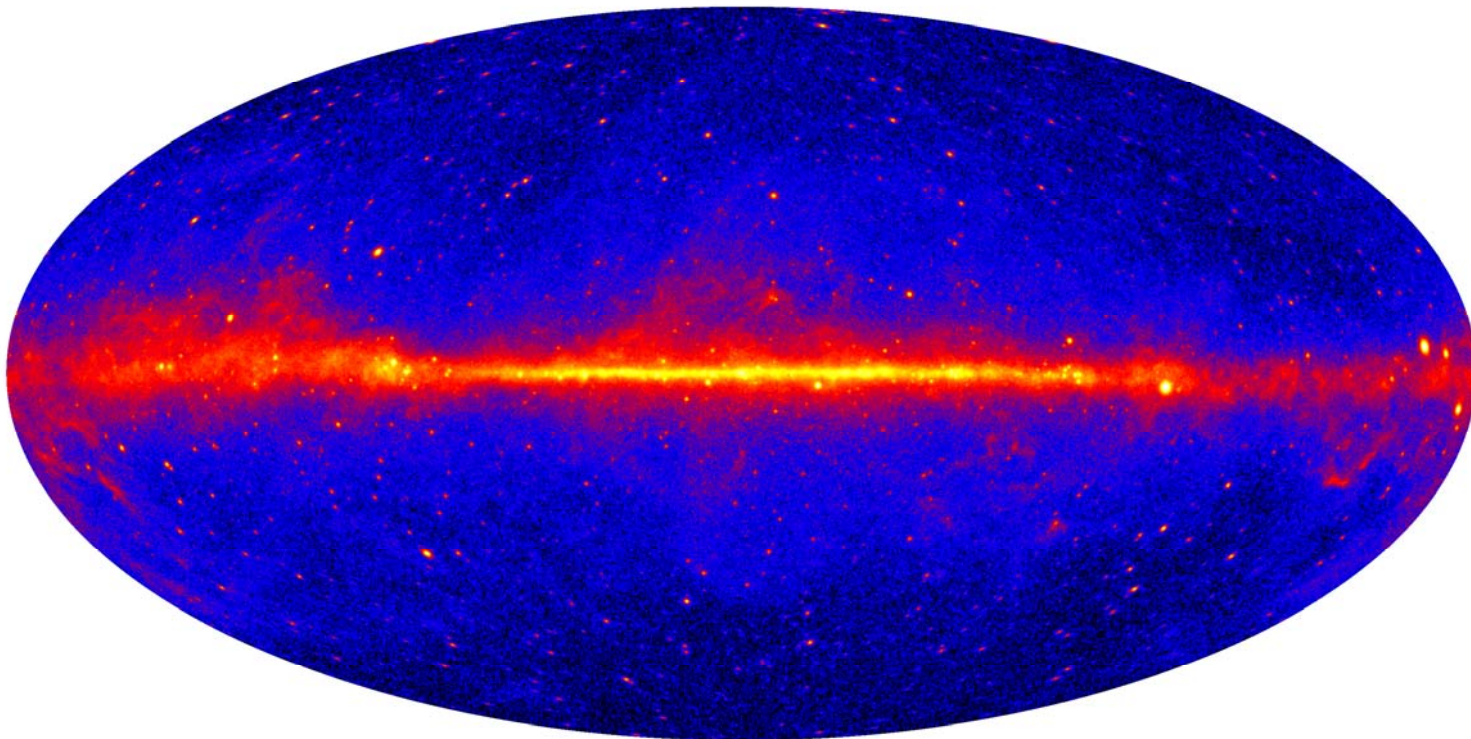
Julie McEnery



# Fermi Status

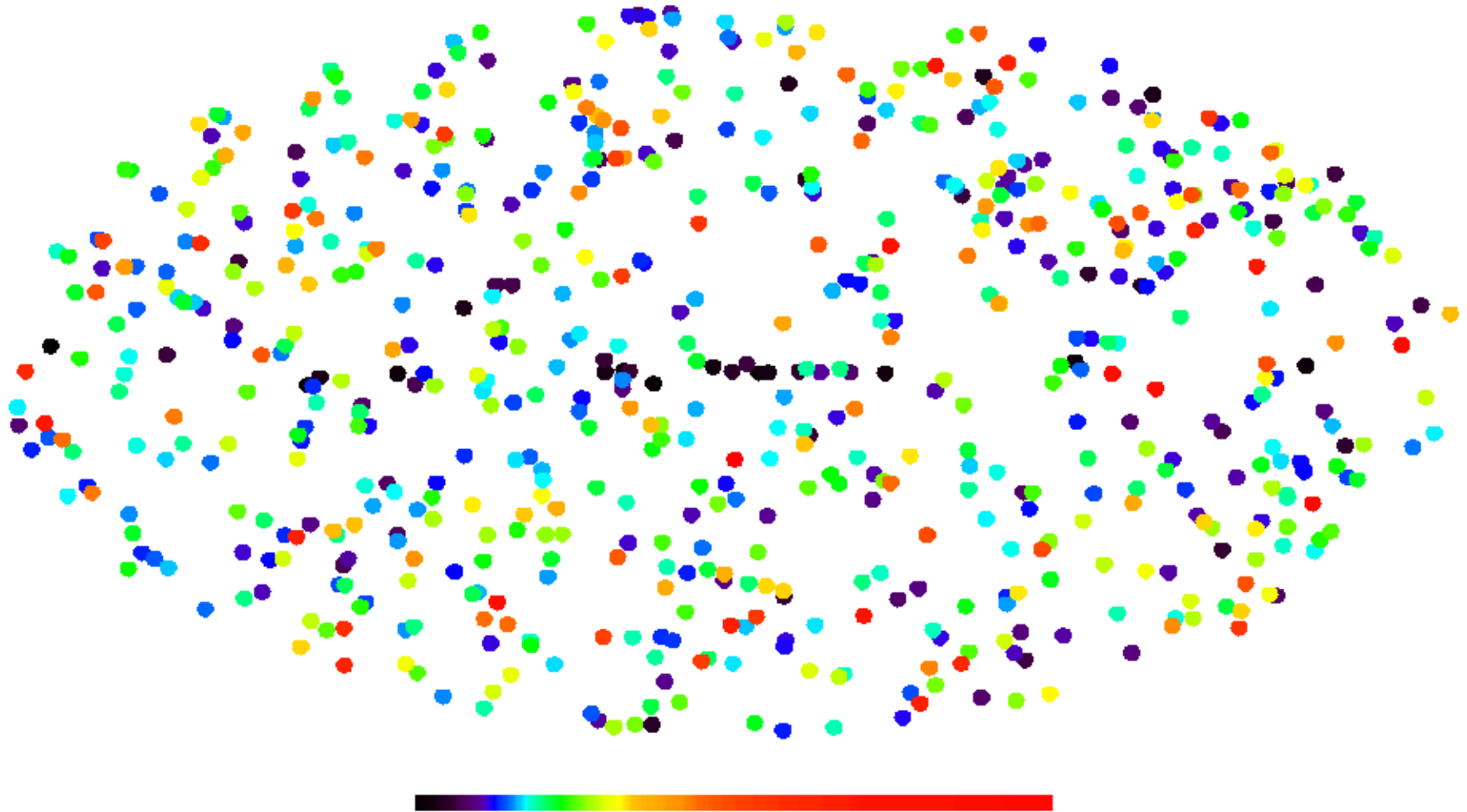
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- **Observatory is operating smoothly**
  - **instruments and spacecraft operate as designed, no degradation in science performance since launch**



# Fermi Status

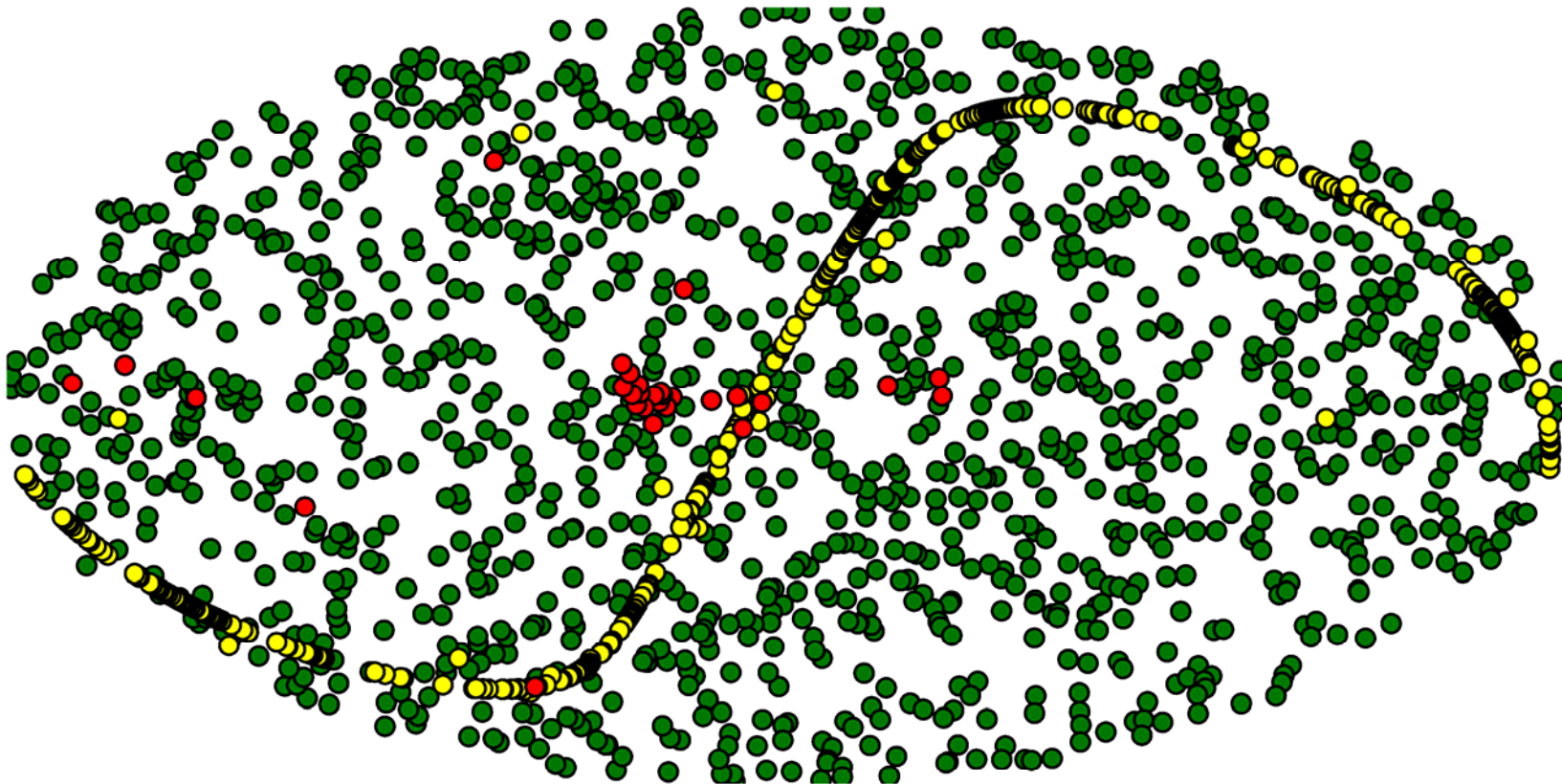
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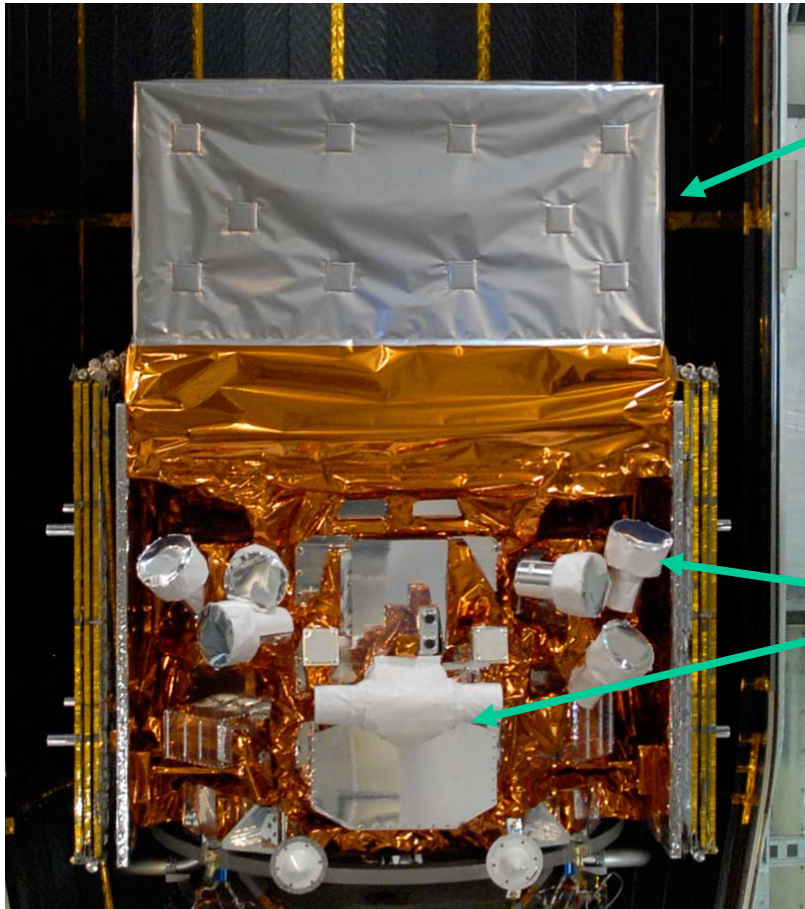
## Fermi Status

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## Fermi instruments



### Large Area Telescope (LAT):

- 20 MeV - >300 GeV (including unexplored region 10-100 GeV)
- 2.4 sr FoV (scans entire sky every ~3hrs)

### Gamma-ray Burst Monitor (GBM)

- 8 keV - 40 MeV
- views entire unocculted sky

- Large leap in all key capabilities, transforming our knowledge of the gamma-ray universe. Great discovery potential.



# Gamma-ray Burst Monitor

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- **Designed to complement high energy LAT GRB observations (GBM does much more than this!)**
  - **Provide rapid localization to allow autonomous repoint to bring GRB to center of LAT FoV**
  - **Detect all bright bursts in unocculted sky (i.e. anywhere not blocked by the Earth)**
  - **Extend sensitivity to high energies for spectral overlap with LAT**
    - **High energy sensitivity provides a boost for detection of short hard bursts relative to other current and previous GRB detectors**
  - **Recently transitioned to continuous Time Tagged Event data (TTE), preliminary tests indicate that this will increase the rate of short GRB to ~80/year (via a ground search)**
- **Summary:**
  - **GBM detects a large number of bright bursts, with a relatively rich fraction of short hard bursts.**

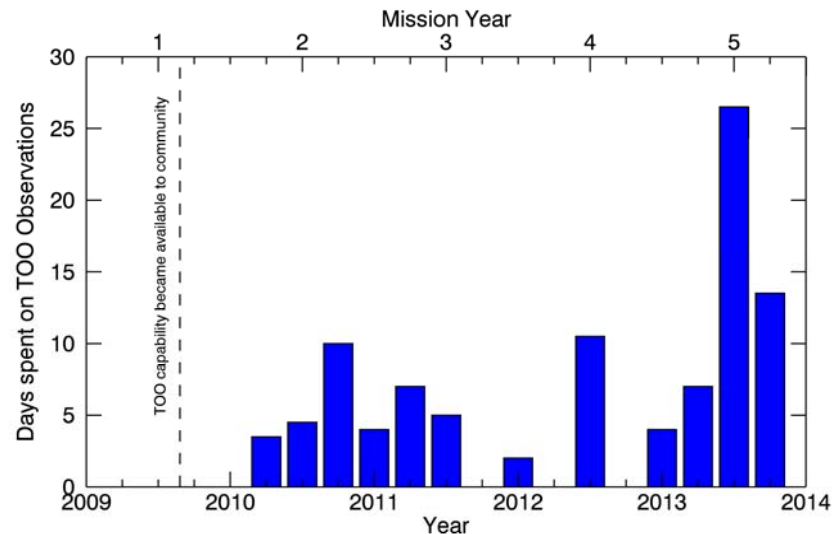
- **Currently serving P7REP data**
  - This has improved calorimeter calibrations relative to P7
    - Better angular resolution at high energies
    - Small shift in the energy scale
  - Updated galactic and isotropic diffuse models
- **Third point source catalog (3FGL)**
  - Based on 4 years of data and P7REP
  - Source list will be released within a few months
  - 3<sup>rd</sup> AGN catalog also in the works

# Observatory Observations

- In Galactic Center-Biased Sky Survey since early December
  - Each orbit contains a mix of pointed mode and survey (fixed rocking angle).
  - Need to be careful with zenith and rocking angle selections.
- Target of Opportunity requests are increasing
  - Requests go straight to FSSC/Project

<http://fermi.gsfc.nasa.gov/ssc/observations/too/>

If you are planning to request a ToO, please submit the form early – we will work with you to evaluate the observation options.





## Observatory cont.

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- **Cycle 7 GI program**
  - **224 proposals**
  - **Review in late April**
  - **Funding starts in October**
- **Senior Review Proposal**
  - **Covers period 2015-2018**
  - **Proposed for mission extension and augmentation of GI program budget (so your success in the GI program may depend on our success in the senior review...)**

## How to work with us

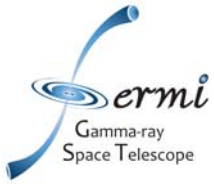
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- **Pick your favorite LAT or GBM team member and talk about what you would like to do**
  - **If you don't know who to contact send a note to Dave Thompson ([david.j.thompson@nasa.gov](mailto:david.j.thompson@nasa.gov)) . He is the MW coordinator for LAT and GBM teams.**
  - **The LAT team member(s) will handle all interactions with the LAT science groups and publication board.**
    - **The intent of LAT team policies is to maintain our identity as a group that works and publishes together, and to maintain a consistently high standard for papers/analysis.**
- **An MOU can cover cases where you would like access to internal information to guide observations (e.g. high energy source list, or flaring source announcements) that are not necessarily tied to a specific analysis or papers**

# LAT Papers

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- For the LAT team, any paper that presents a new analysis of LAT data and has LAT authors is a LAT paper.
  - Cat 1 paper – major LAT result, authorship open to all LAT members, LAT author list block ordered alphabetically, 2 internal reviewers
  - Cat 2 paper – LAT authorship open only to those who directly participated in the paper, LAT author list block ordered at the discretion of the authors, 1 internal reviewer
  - Determination of whether a paper is cat 1 or 2 is by the science group leads (but they usually go with the recommendation of the authors)
  - LAT publication board approval needed before paper is submitted



# Questions?

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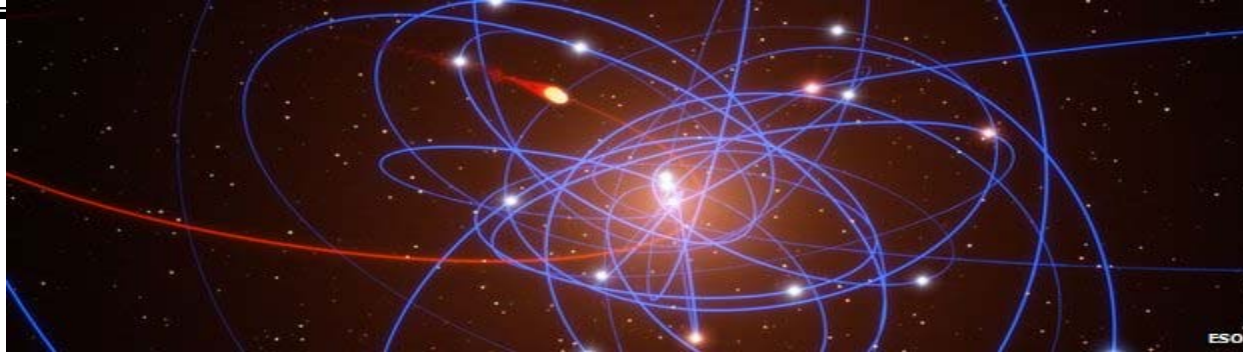
# Science case for GC observation: Pulsars

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- **Pulsar science is a major Fermi success story!**
  - **Many pulsars of many types discovered**
  - **Significant boost in our understanding of these objects**
- **Marked increase in sensitivity for pulsed searches near the Galactic center where the population of pulsars should be very large**
  - **Very high probability to detect new gamma-ray pulsars**
- **In the close vicinity of SgrA\*, pulsation searches would have to account for accelerations due to orbital variability, orbital periods as short as 300 days could be found with a year-long observation**
  - **Possible probe of strong field gravity (if we are lucky enough to find a pulsar close to SgrA\*)**
- **Most young pulsars do not have stable timing for longer than a year or so**
  - **Optimum observation duration for pulsar search is 1 year**



# Science Case for a GC Observation: G2 passage



- A gas/dust cloud is approaching SgrA\* in highly eccentric orbit
  - Pericenter is only 36 light hours (or  $\sim 3100$  Schwarzschild radii)
  - Accretion flow near SgrA\* may become dominated by this cloud
    - As the cloud breaks up and fragments feed into the central accretion flow, there may be giant radiation flares
  - Duty cycle of high energy activity may be increased (i.e. more IR/X-ray flares), gamma-ray observations can test models of flare emission
  - Lots of other observatories are pointing towards the galactic center – significant chance for serendipitous discoveries
- GC is close to pericenter now – Fermi observation at GC is most useful ASAP



# Gamma-ray Burst Monitor

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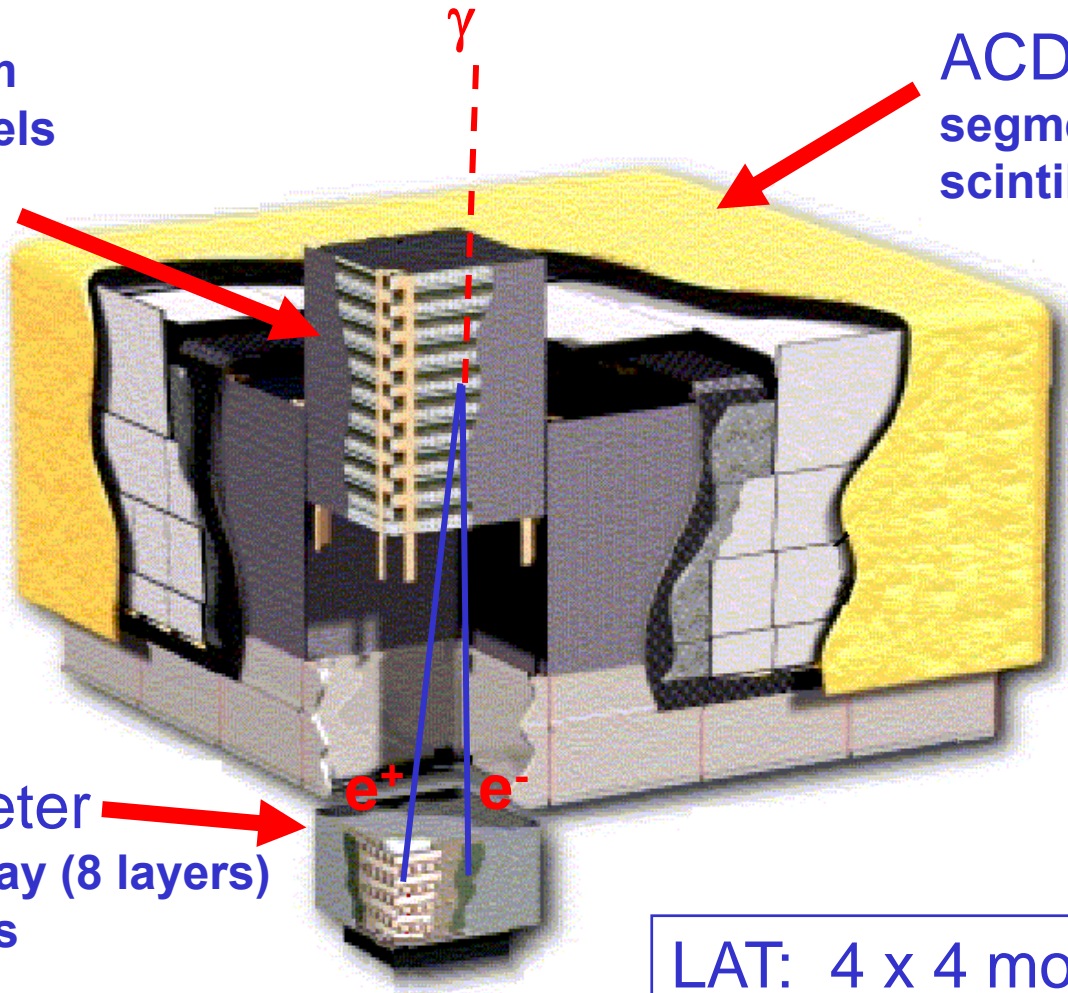
- **>9.5sr FoV (~ entire unocculted sky)**
- **250 GRB/year (triggered onboard)**
- **8 keV - 40 MeV (broader energy range than BATSE)**
  - **Overlap with LAT energy range (connects LAT observations with “traditional” GRB range)**
  - **Extension to high energies improved sensitivity to short hard bursts**
- **Localization of GRB by GBM**
  - **<15 degrees initially (calculated onboard within 2 s), designed to provide repoint location for LAT afterglow observations**
  - **Refinements with ground analysis within ~15-30 mins of GRB trigger**
- **Onboard GRB trigger**
  - **More flexible trigger algorithm compared with BATSE -> improved sensitivity to very short GRB and to long soft GRB.**
  - **Onboard trigger classifications (solar flare, particle event, GRB etc)**
  - **Provides repoint recommendation to allow high energy afterglow observations with the LAT**
  - **Provide rapid alert to GRB afterglow observers (via GCN)**

# The Large Area Telescope

## Si Tracker

pitch =  $228\ \mu\text{m}$   
 $8.8 \cdot 10^5$  channels  
18 planes

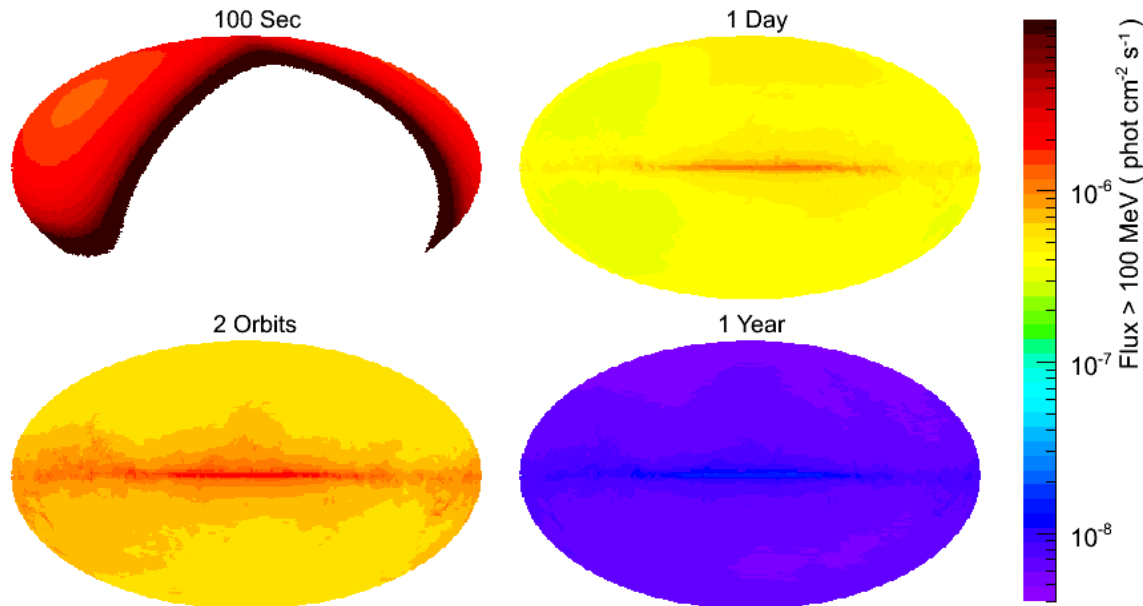
ACD  
segmented  
scintillator tiles



CsI Calorimeter  
hodoscopic array (8 layers)  
 $6.1 \cdot 10^3$  channels

LAT: 4 x 4 modular array  
3000 kg, 650 W  
20 MeV – 300 GeV

# All Sky Coverage

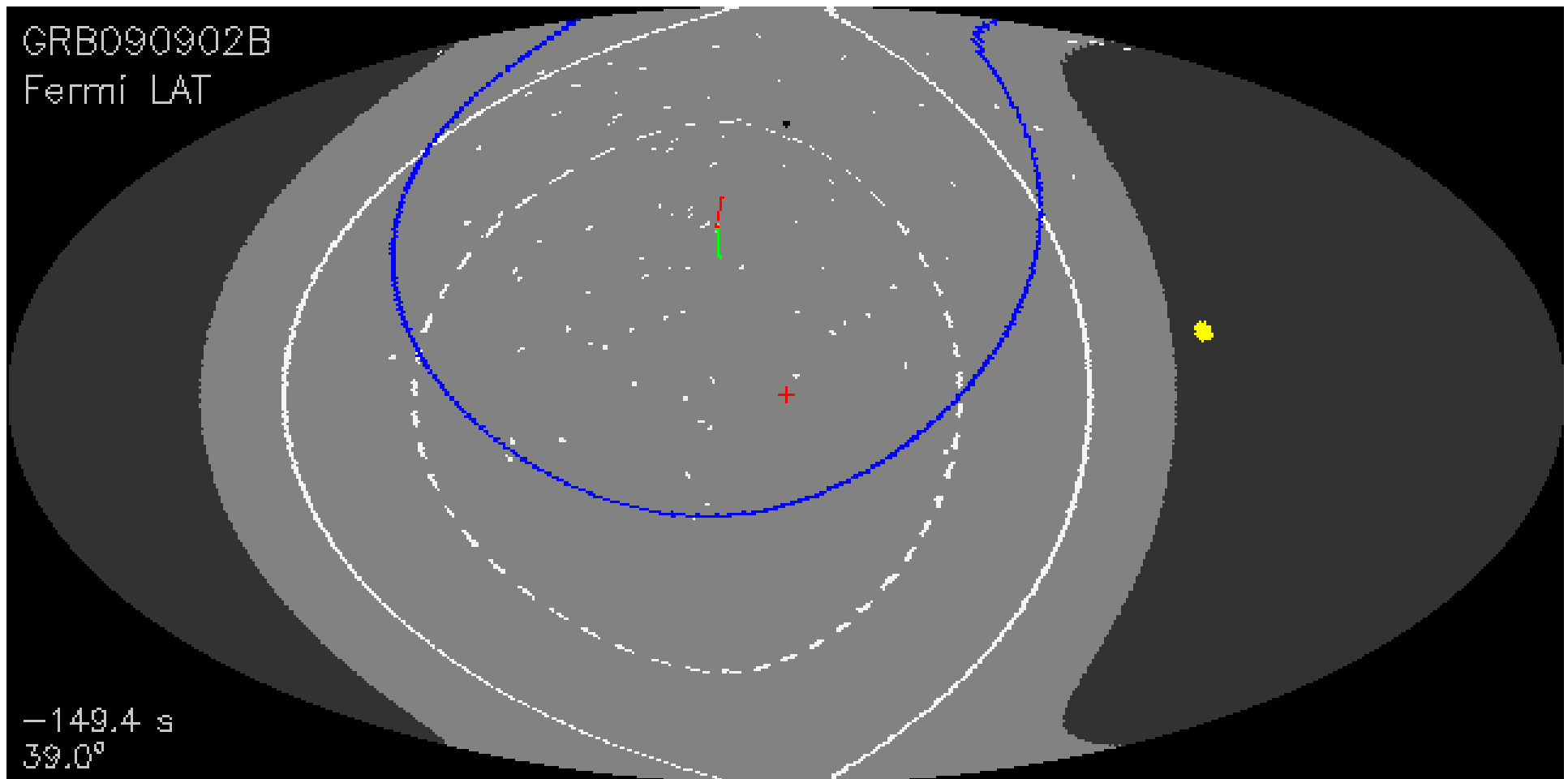


**LAT sensitivity on 4 different timescales: 100 s, 1 orbit (96 mins), 1 day and 1 year**

- In survey mode, the LAT observes the entire sky every two orbits (~3 hours).
- Multiwavelength/multimessenger observations in coordination with the LAT are limited only by the ability to coordinate to other observations in other wavebands.
- Can also perform pointed observations of particularly interesting regions of the sky.

## GRB090902B - Autonomous repoint

- LAT pointing in celestial coordinates from -120 s to 2000 s
  - Dark region = occulted by Earth ( $\delta > 113^\circ$ )
  - Blue line = LAT FoV ( $\pm 66^\circ$ ), White points = LAT events



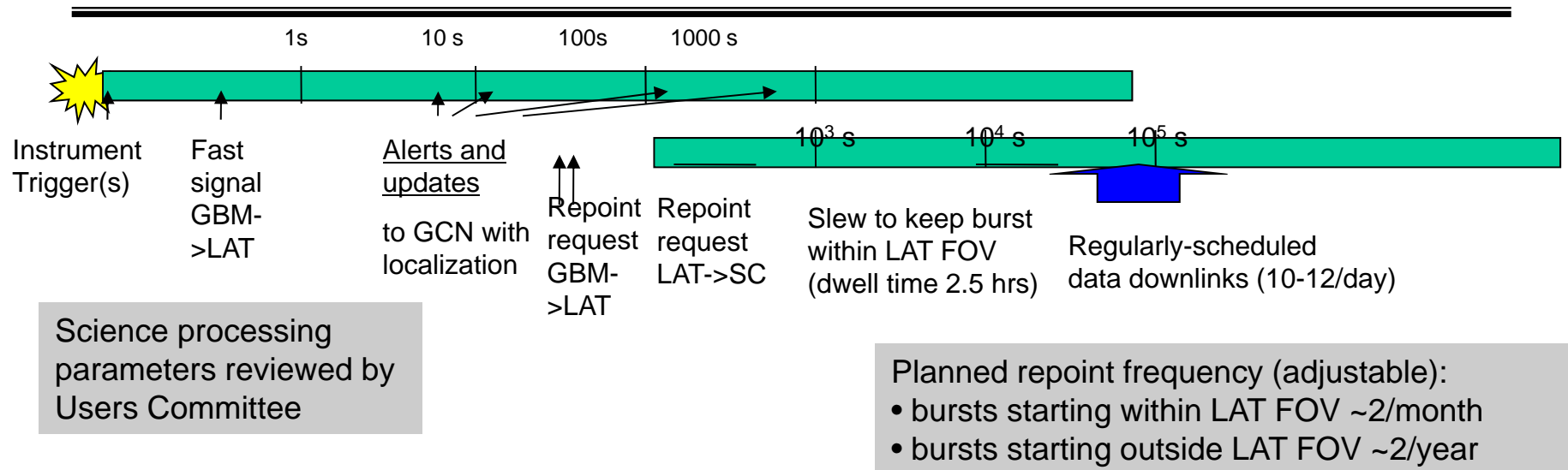


# Spacecraft performance

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- **Pointing knowledge**
  - **<10 arcseconds, using 2 star trackers (a third is available as a spare)**
- **Absolute Timing**
  - **Better than 300 ns, using GPS and oscillators**
- **Orbit location (knowing where we are)**
  - **~<10m using GPS**
- **Observing modes**
  - **Survey**
    - **view entire sky every 2 orbits, efficient as the Earth does not enter the LAT FoV.**
  - **Inertially pointed**
    - **Scheduled - planned observation at an interesting location**
    - **Autonomous - to automatically put or keep a GRB location within the FoV of the LAT**
  - **Slew requirement of 75 deg in 10 mins, but can reach max slew rates of 0.3 deg/s**

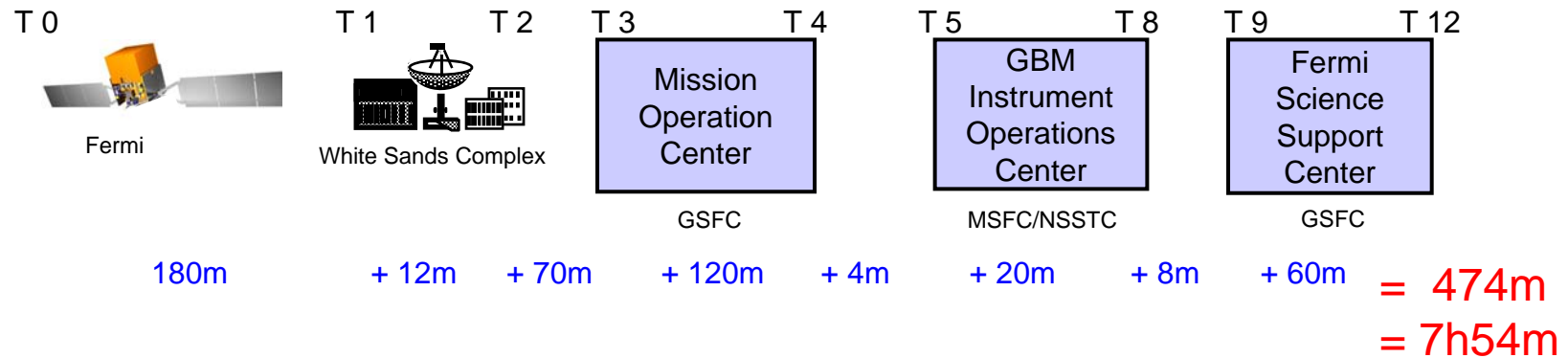
# Alerts and Data Flow



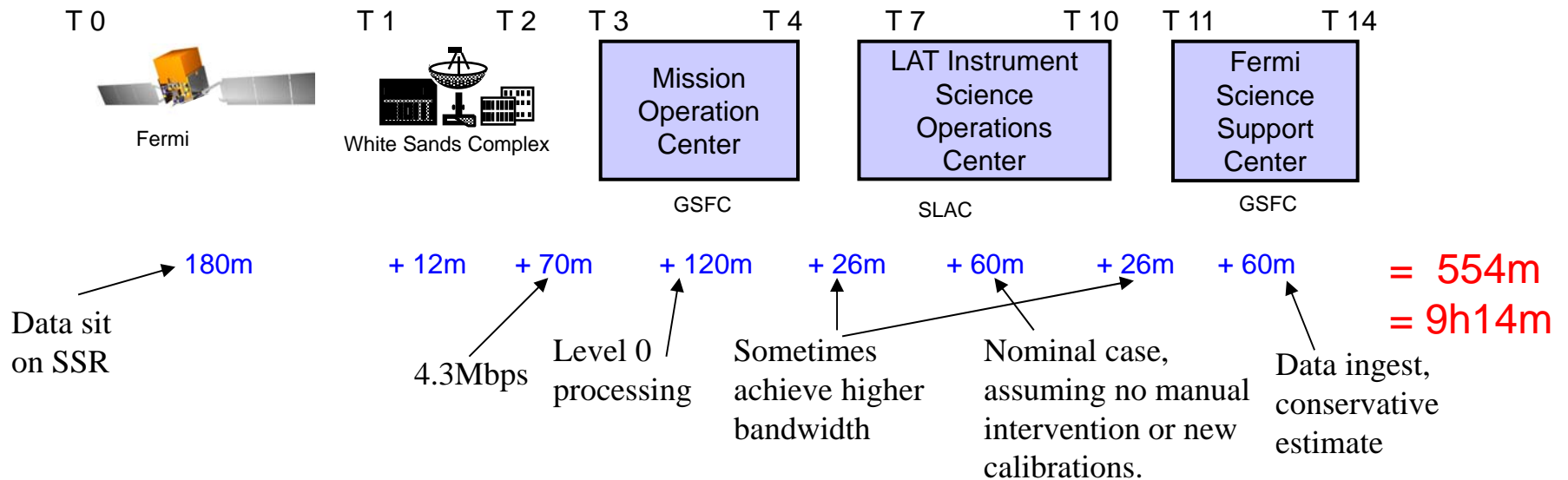
- Onboard processing (both LAT and GBM) - GCN alerts: **location, intensity (cnts), hardness ratio, trigger classification (GRB, solar flare etc)**
- GBM Prompt ground processing (10-30 mins): **updated location, lightcurve**
- LAT ground processing (5-12 hours): **updated location, high energy spectrum, flux (or upper limit), afterglow search results**
- Final ground processing (24-48 hours): **GBM model fit (spectral parameters, flux, fluence), joint LAT-GBM model fit, raw GBM data available. Year 2 and beyond - LAT count data available.**

# Data Latency

## GBM DATA PATH

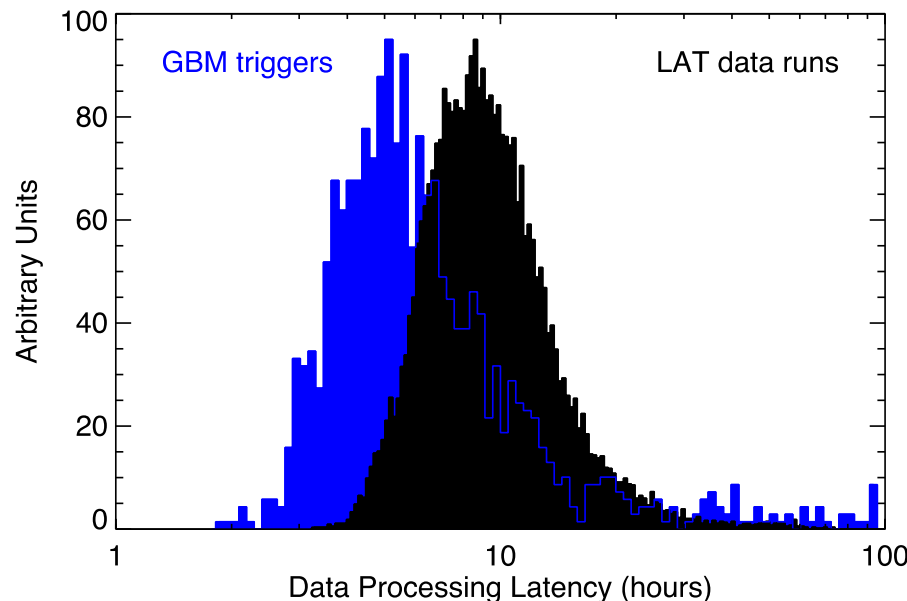


## LAT DATA PATH



# Data Availability

No proprietary gamma-ray data - Everyone gets access to the data at the same time



Latency requirement is 72 hours, typical latency is much less  $\sim < 10$  hours

- All data and software release milestones met at or ahead of schedule
- LAT and GBM instrument teams generate additional high level data (lightcurves, transient alerts, pulsar timing solutions etc) which are served to the community by the FSSC



# The Future

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- **No consumables, orbit is good until at least 2050**
  - **Mission will likely be able to continue as long as there is funding**
- **No degradation in science performance of instruments**
  - **Improvements in LAT reconstruction and event selections tuned to specific science studies have resulted in improvements in performance since launch**
  - **Operational improvements in GBM (now collecting event-based data), provide enhanced capability**
- **Fermi was proposed as a 10-year mission (5 year requirement, 10 year goal)**
  - **Planned mission continues to at least 2018 (subject to successful senior review)**





## Fermi Users Group Members

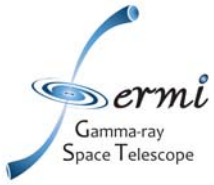
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- Erin Bonning
- Fernando Camilo
- Wei Cui
- Doug Finkbeiner
- Dale Frail (Chair)
- Dieter Hartmann
- Jamie Holder
- Buell Januzzi
- Savvas Kousiappas
- Don Kniffen
- Anna Watts

### *Plus*

- Neil Gehrels
- Ilana Harrus
- Julie McEnery
- Bill Paciesas
- Peter Michelson
- Steve Ritz
- Chris Shrader
- Dave Thompson
- Kathy Turner
- Lynn Cominsky

***<http://fermi.gsfc.nasa.gov/ssc/resources/guc/>***



# The Large Area Telescope

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## Fermi Science Support Center (FSSC)

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- **Supports guest investigator program (Cycle 3 deadline Feb 4)**
- **Provides training workshops**
- **Provides data, software, documentation, workbooks to community**
- **Archives to HEASARC**
- **Joint software development with Instrument Teams, utilizing HEA standards**
- **Located at Goddard**

see <http://fermi.gsfc.nasa.gov/ssc/>

and help desk

<http://fermi.gsfc.nasa.gov/ssc/help/>

# Data Releases

- Beginning of science operations: GBM data + LAT high level data from start of science operations
- Feb 6, 2009: LAT bright source list, first LAT analysis software release
- Aug 25, 2009: low level LAT data, second LAT analysis software release

- ~400 queries in first day, many requesting the entire dataset.
- Made link to weekly all-sky files more obvious (so number of queries dropped)

